Graduate Res. Ctr. of Texas

SEMIANNUAL STATUS REPORT ON
"INVESTIGATIONS INTO THE MECHANISM AND RATES OF
ATMOSPHERIC MIXING IN THE LOWER THERMOSPHERE"
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The effects of eddy mixing in the lower thermosphere on atmospheric composition have been evaluated for a number of different rates of eddy mixing, characterized by coefficients in the range from 2 to 8 x 10^6 cm^2 sec^{-1}. The computing program has been modified so as to include the effects of broad-scale vertical currents, and present efforts are devoted to defining realistic vertical velocities for use in this program. This should make possible the realistic evaluation of the atmospheric structure perturbations that might be caused by vertical currents.

The results of calculations, without taking into account the effects of vertical currents, have been compared with argon-nitrogen ratios measured by Nier and others. At this point, the agreement is not good, the argon concentrations frequently being smaller than anticipated by a factor as high as ten. Other constituents also deviated substantially from that predicted on the basis of earlier observed results. The atomic-to-molecular-oxygen ratio was low, indicating a higher than normal mixing rate, and a relatively high helium concentration, which was also observed, seems to corroborate this conclusion. The answer may lie in the pattern of mixing; for example, a period of enhanced mixing between two arbitrary altitudes over a specified time period. Of course, another possibility is that there is some error in the observations, as they did not extend to low enough altitude to provide a basis for comparison with the mixed atmosphere.

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The influence of internal gravity waves on eddy mixing has undergone continued study. There is good agreement in the rate of energy loss by internal gravity waves in the upper atmosphere, as calculated by Hines (J. Geophys. Res., 70, 177, 1965), and the rate of turbulence energy dissipation determined by Justus (J. Geophys. Res., 71, 3767, 1966). This suggests that gravity waves may be a source of the turbulence.

While the wind shears associated with internal gravity waves are not of sufficient magnitude to cause turbulence, it now appears that the temperature fluctuations may become of great enough amplitude to produce spatially periodic, unstable regions, in which the temperature lapse is temporarily superadiabatic. In the near isothermal region of the atmosphere, between 80 and 90 km, such conditions may be expected when

$$\left|U_x\right| \lambda_x^{-1} < 3.5 \times 10^{-3} \text{ sec}^{-1}$$

where U_x is the velocity of horizontal motion in the gravity wave, and λ_z is the vertical component of its wavelength. According to Kochanski (J. Geophys. Res., 69, 3651, 1964), the mean horizontal velocity ranges from 25 to 40 m sec^{-1} between 80 and 95 km, while the mean vertical wavelength is about 11 km. Thus spatially periodic, unstable conditions may occur with probability of 50% at 95 km, but with decreasing likelihood at lower altitudes. The influence of these instabilities on the production of turbulence and on eddy mixing is now being studied.

The experimental apparatus to investigate means of measuring atomic oxygen in the lower thermosphere has been completed, and some experiments

have been run. The apparatus has been slightly damaged by an explosion of accumulated combustible gases in the exhaust line, and repairs are being made. It is not expected that significant delay will be caused by this mishap.

The following papers have been published under this grant:

Colegrove, F. D., F. S. Johnson, and W. B. Hanson, "Atmospheric Composition in the Lower Thermosphere," J. Geophys. Res., 71(9), 2227-2236, 1966.

Johnson, F. S., "Density of an Exosphere," Ann. Geophys., 22, 86-91, 1966.

Johnson, F. S., "Eddy Diffusion in the Lower Thermosphere," to be published in SPACE RESEARCH VII, 1966.

Johnson, F. S., "Turbopause Processes and Effects," presented at the COSPAR Seventh International Space Science Symposium, Vienna, Austria, May, 1966, and to be published in SPACE RESEARCH VIII, 1967.

Midgley, J. E., "Calculation of Subdominant Solutions of Linear Differential Equations," J. Soc. Industrial and App. Math., Series B: Numer. Anal., 3, #1, 56-66, 1966.

Midgley, J. E., and H. B. Liemohn, "Gravity Waves in a Realistic Atmosphere," to be published in J. Geophys. Res., 1966.